BATTERY CHARGER FOR PORTABLE DEVICES AND RELATED METHODS

Field of the Invention

[0001] The present invention relates to the field of battery-powered portable devices, and, more particularly, to battery chargers for such portable devices and related methods.

Background of the Invention

[0002] Rechargeable batteries are used in a wide variety of portable devices such as laptop computers, cellular telephones, personal digital assistants (PDAs), etc. With the rapid increase in portable device technology, it is fairly common for users to replace their portable devices at frequent intervals. However, users may be required to also purchase new battery chargers when upgrading portable devices, because of different connector types or battery types used for different portable devices.

[0003] In some cases, the use of standardized interfaces or connectors for portable devices allows a

single battery charger to be used for charging different portable devices. For example, many portable devices now support the universal serial bus (USB) protocol, and include one or more USB connectors which allow them to be connected to personal computers (PCs), etc. Further details regarding the USB protocol and connectors may be found in the Universal Serial Bus Specification, Revision 2.0, April 27, 2000, published by USB Implementers Forum, Inc., which is hereby incorporated herein in its entirety by reference. Thus, a charger having a USB connector could potentially be used to charge different portable USB devices.

[0004] An example of such a charger is disclosed in U.S. Patent No. 6,184,652 to Yang. This patent is directed to a mobile phone battery charger with a USB interface that includes a USB compatible plug, a DC converter, and a mobile phone battery charging plug. The USB compatible plug is inserted into a corresponding USB connector of a computer and receives electrical power therefrom. The DC converter converts the electrical power into the necessary charging voltage, which is provided to the mobile phone by the battery charging plug. The battery charger may also detect the type of mobile phone battery (e.g., Li or Ni-MH) and the quantity of electricity or charge stored in the battery. The patent states that a user accordingly need not purchase different kinds of chargers for different battery types.

[0005] Another example is disclosed in U.S. Patent No. 6,362,610 to Yang. More particularly, this patent discloses a universal USB power supply unit which includes a USB port connector and a charging connector. The USB port connector plugs into the jack of the USB

port, while the charging connector plugs into the jack of an electronic product to be charged. The current flowing into the USB port connector will then pass through an automatic voltage regulator. Disposed within a housing of the automatic voltage regulator is a DC voltage transformer which transforms the DC voltage (e.g., 5 V) coming from the USB port to the requisite voltage supplied to a power/signal connecting jack. A feedback control voltage output circuit compares the feedback voltage signal of the power/signal connecting jack and enables the DC voltage transformer to output a preset voltage. The charging connector is fitted with a power cord which includes a power/signal connector to fit the power/signal connecting jack. Moreover, a voltage parameter associated with the particular electronic device is preset within the charging connector using a variable resistor.

[0006] Despite the advantages of such chargers, problems may still arise when different types of batteries are interchanged in different portable devices. That is, different rechargeable batteries may have different charging parameters (e.g., voltage rating, current rating, etc.). Yet, these parameters may not always match with those of a given portable device. Accordingly, using chargers such as those described above where the battery and device charging parameters are not carefully matched could result in damage to the device and/or battery.

Summary of the Invention

[0007] In view of the foregoing background, it is therefore an object of the present invention to provide a battery charger that may be used with numerous types

of portable devices and associated batteries, and yet which may account for differences between the charging parameters thereof.

[0008] This and other objects, features, and advantages in accordance with the present invention are provided by a battery charger which may include a charger connector to be coupled to a corresponding device connector of a portable device including a rechargeable battery. The portable device and rechargeable battery may each respectively have a portable device type and a rechargeable battery type associated therewith from among a plurality of different portable device types and different battery types. The battery charger may also include a charging circuit connected to the charger connector, and a controller connected to the charger connector and the charging circuit. More particularly, the controller may be for causing a portable device connected to the charger connector to identify its corresponding portable device type and its corresponding rechargeable battery type, and cause the charging circuit to charge the rechargeable battery based thereon.

[0009] More particularly, different portable device types may have one or more different portable device charging parameters, and different battery types may similarly have one or more different battery charging parameters. For example, different types of batteries may have different voltage and/or current limits than one another, and different devices may similarly have different voltage and/or current limits as well. As such, the controller may advantageously select one or more actual charging parameters to charge the rechargeable battery based upon a comparison of the

different portable device and battery charging parameters to avoid damaging one or the other.

[0010] By way of example, a particular rechargeable battery may have a higher voltage and/or current limit associated therewith than the portable device it is carried by. In such case, charging the battery at its highest rated voltage/current level could cause damage to the portable device. Accordingly, the controller may select the actual charging parameter(s) based upon a limiting one of the different portable device and battery charging parameters. Thus, the controller may prevent the battery from being charged using a charging parameter that could damage either the portable device or the battery.

[0011] Moreover, the controller may also cause the portable device to identify a battery charge level of the rechargeable battery. Accordingly, the controller may further select the actual charging parameter(s) based upon the battery charge level. Thus, for example, the controller may select an actual charging parameter such as charging time based upon the charge level of the battery and a maximum charging time for the battery.

[0012] The battery charger may further include one or more memories connected to the controller for storing the different portable device/battery charging parameters. That is, the memory may store the appropriate device and battery charging parameters for each type of portable device and rechargeable battery to be used with the battery charger. Yet, to allow for use of the charger with future generations of portable devices and batteries, the controller may advantageously enter a learning mode for learning the

at least one different portable device or battery charging parameter.

[0013] More specifically, the controller may enter the learning mode upon receiving a learning mode signal from the portable device. For example, if a portable device of an unknown device type, or which has an unknown battery type, is connected to the charger connector, the controller may provide an error signal to the portable device based thereon. The portable device may then provide the learning mode signal to the controller and communicate the appropriate charging parameter(s) thereto once the controller enters the learning mode. As such, the newly learned charging parameter(s) may advantageously be stored in the memory and used upon future connections of the device and/or battery type to the battery charger.

[0014] Additionally, the charger connector may also carry communications signals between the controller and a host device (e.g., a computer) connected thereto. More particularly, the communications signals may relate to at least one charging parameter. That is, the controller may advantageously learn charging parameters from the host device as well the portable device. Furthermore, in some embodiments the charger connector may also carry communications signals between the portable device and the host device. Thus, the battery charger may provide a docking station between the portable device and the host device. This arrangement may be particularly advantageous for portable devices such as personal digital assistants (PDAs) which not only have portable batteries, but which frequently are also used to synchronize calendar, contact, email, and other data with a computer.

[0015] The controller may also monitor the charging circuit to detect a charging error during charging of the rechargeable battery. By way of example, such charging errors may include over or undervoltage conditions, over or undercurrent conditions, excessive temperatures, exceeding a maximum charging time, etc. The battery charger may also include an indicator connected to the controller for providing an error indication upon detecting the charging error. For example, the error indicator could be an LED or LCD display. Also, the charger connector may be a universal serial bus (USB) connector, for example.

[0016] A battery charging system in accordance with the invention may include a portable device including a device connector and a rechargeable battery. The system may also include a battery charger for the portable device, such as the one described briefly above.

[0017] A battery charging method aspect of the invention for a rechargeable battery carried by a portable device may include coupling a device connector of the portable device to a corresponding charger connector, and connecting a charging circuit to the charger connector. The method may further include causing the portable device to identify its corresponding portable device type and its corresponding rechargeable battery type via the charger connector from among a plurality of different portable device types and different battery types, and causing the charging circuit to charge the rechargeable battery based thereon.

Brief Description of the Drawings

[0018] FIG. 1 is schematic block diagram of a battery charging system in accordance with the present invention.

[0019] FIG. 2 is a more detailed schematic block diagram of an embodiment of the battery charger illustrated in FIG. 1.

[0020] FIG. 3 is a flow diagram illustrating a battery charging method in accordance with the present invention.

[0021] FIG. 4 is a flow diagram illustrating a method for identifying the battery charger to the portable device of FIG. 1.

[0022] FIG. 5 is a schematic block diagram of an exemplary portable device for use with the present invention.

Detailed Description of the Preferred Embodiments

[0023] The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

[0024] Referring initially to FIG. 1, a battery charging system **20** includes a portable device **21** including a rechargeable battery **22** carried thereby, and a battery charger **23** for charging the rechargeable battery. An exemplary portable device suitable for use

with the present invention is described in the example below with reference to FIG. 5. The charger **23** illustratively includes a charger connector **24** to be coupled to a corresponding device connector **25** of the portable device **21**. The battery charger **23** also illustratively includes a charging circuit **26** connected to the charger connector **24**, and a controller **27** connected to the charger connector and the charging circuit.

[0025] By way of example, the portable device **21** could be any one of a laptop computer, personal digital assistant (PDA), mobile telephone, or other portable device having a rechargeable battery. More particularly, the battery charger **23** may advantageously be used with numerous types of portable devices and rechargeable batteries as well, as will be described further below. Generally speaking, the portable device **21** will include control circuitry for performing its various device functions, such as the microprocessor **30**. Moreover, many portable devices also include interface circuitry **31** for interfacing the microprocessor **21** with a data bus or cable, for example, that connects the portable device with a host device (e.g., a computer).

[0026] By way of example, the portable device **21** may be a USB compatible device, and the device connector **25** a USB connector. In this case, the interface circuitry **31** may perform a variety of operations such as connecting high or low logic signals to the differential data lines D+ and D- during enumeration with a host device, as will be appreciated by those skilled in the art. Moreover, the interface circuitry **31** may also perform signal buffering as well as signal

translation for converting differential signals to data signals recognizable by the microprocessor **30**, and vice-versa. The interface circuitry **31** may also connect the USB voltage references V_{BUS} and GND from the host device to the appropriate components in the portable device **21** (e.g., the rechargeable battery **22** when the portable device is in a charging mode). As will be readily appreciated by those skilled in the art, different interface and control circuitry configurations may be used for the portable device **21** depending upon the given application.

[0027] For clarity of understanding, the present discussion will refer to the case in which the battery charger **23** is for charging portable devices which operate in accordance with the USB protocol and thus include a USB connector **25**, as described above. However, it will be understood by those of skill in the art that the battery charger **23** may be used with numerous types of devices and operational protocols, such as those using serial or parallel communications interfaces, etc. Moreover, it should also be noted that in some embodiments the battery charger **23** may include multiple connectors **24** for different types of device connectors **25**. Thus, for example, the battery charger **23** could be used to charge both USB devices and those which communicate using a serial (or other) communications interface.

[0028] An exemplary embodiment of the battery charger **23** for USB devices and operation thereof will now be described with reference to FIGS. 2 and 3. More particularly, beginning at Block **40**, upon connection of the device connector **25** to the charger connector **24**, the controller **27** causes the portable device **21** (i.e.,

the microprocessor **30**) to identify its corresponding portable device type and its corresponding rechargeable battery type from among a plurality of different portable device types and different battery types, at Block **41**. The device type may be stored as a device identification (ID) in a non-volatile memory of the portable device **21** (e.g., an EEPROM), and the battery type may be identified by the microprocessor **30** from an identification circuit carried by the battery **22**, for example.

[0029] It should be noted that device and battery "types" may vary depending upon a given implementation of the present invention. For example, in some applications, device/battery types may be respective models of portable devices/batteries. However, in other applications, the device/battery types may correspond to a particular series of portable devices/batteries. For example, a manufacturer may make one base portable device but put different connectors thereon for different applications. As such, the base device may have the same charging parameters, but it will be assigned a different model number within a series (e.g., the 6000 series) depending upon the particular connector used therewith. Thus, in such cases the device type would include all of the devices within the given series. Similarly, device/battery type could also correspond to the manufacturer thereof in other applications (i.e., all devices by a particular manufacturer are of the same device type).

[0030] Various approaches may be used for causing the portable device **21** to identify its battery and device types. One particularly advantageous approach for USB compatible devices is for the controller **27** to

initially place a logic high signal on both of the differential D+ and D- data lines when the connectors **24, 25** are first connected. This is an otherwise invalid USB enumeration state, but for an appropriately configured portable device **21** this would indicate that the device has been connected to the battery charger **23**. As such, the portable device **21** may then suspend the normal USB enumeration operations it would otherwise use if connecting to a host device, for example, and instead enter a charging mode.

[0031] An exemplary implementation of this approach will now be described in greater detail. When the battery charger **23** is connected to the portable device **21**, the controller **27** preferably provides an identification signal to the portable device to notify the portable device that it is connected to a power source that is not subject to the power limits imposed by the USB specification. Preferably, the portable device **21** is programmed to recognize the identification signal, and it therefore recognizes that an identification signal has been transmitted by the controller **27**. After recognizing a valid identification signal, the portable device **21** is then ready to draw power from the charger **23** without performing USB enumeration.

[0032] The detection of the identification signal may be accomplished using a variety of methods. For example, the microprocessor **30** may detect the identification signal by detecting the presence of an abnormal data line condition at the USB port **25**, for example. As noted above, one exemplary identification signal results from the application of voltage signals greater than two volts to both the D+ and D- lines by

the controller **27**. The foregoing will be further understood with reference to FIG. 4.

[0033] Beginning at Block **220**, the portable device **21** detects the presence of a voltage on the Vbus line of the USB connector **25**, at Block **210**. The mobile device **21** then checks the state of the D+ and D- lines, at Block **220**. The D+ and D- lines are compared to a 2V reference, for example. The controller **27** of the charger **23** may apply a logic high signal, such as +5V reference, to both the D+ and D- lines. If the voltages on both the D+ and D- lines are greater than 2V, then the portable device **21** determines that it is not connected to a typical USB host or hub, and that the charger **23** has instead been detected (Block **230**). The portable device **21** is then ready to charge the battery or otherwise use power provided via the Vbus and Gnd lines (Block **260**) without waiting for enumeration, and without being limited by the power restrictions imposed by the USB specification, as will be appreciated by those skilled in the art.

[0034] It should be noted that the charger **23** may also serve as an interface to a host device or hub (e.g., a personal computer (PC)) as well as a charging station in some embodiments. In this case, the portable device **21** may still go through the enumeration process. More particularly, if the portable device **21** detects the presence of a voltage on the Vbus line (meaning the charger **23** is connected to the host device) and also determines that the voltages on both the D+ and D- lines are not greater than 2V (Block **220**), then the portable device determines that a USB host or hub has been detected (Block **240**). A typical USB host or hub weakly holds its D+ and D- lines at zero volts when it

is not connected to another device. The portable device **21** may then signal the USB host or hub to initiate the enumeration process (Block **250**) and can use power provided via the Vbus and Gnd lines (Block **260**) in accordance with the power limits imposed by the USB specification and/or communicate with the host device, thus concluding the illustrated method (Block **270**).

[0035] Of course, battery charging could also be performed at this point, but it would be subject to the power restrictions imposed by the USB specification, as will be appreciated by those of skill in the art. The enumeration process is typically initiated after the portable device **21** applies approximately zero volts to the D- line and approximately 5V to the D+ line to inform the host of the portable device's presence and communication speed, as will also be appreciated by those skilled in the art. It should be noted that if no USB host is present, the portable device **21** may disable its typical USB functions in some embodiments, if desired.

[0036] Different portable device types will typically have one or more different portable device charging parameters, and different battery types may similarly have one or more different battery charging parameters. Table 1 provides exemplary charging parameters for two different types of USB compatible PDAs, while Table 2 provides exemplary charging parameters for two different types of PDA batteries.

Table 1 - Exemplary Device Charging Parameters

Device Charging Parameter	Device Type #1	Device Type #2
Overvoltage limit (V)	6.0	5.25
Undervoltage limit (V)	4.0	4.8
Overcurrent limit (mA)	800	400

Constant current (mA)	750	350
Battery full (mA)	40	20
Battery full (V)	4.15	4.22

Table 2 - Exemplary Battery Charging Parameters

Battery Charging Parameter	**Battery Type #1**	**Battery Type #2**
Max. Charge time (Hours)	4.0	8.0
Battery Capacity (mAh)	1000	2000

[0037] As may be seen from the tables, device type #1 can tolerate voltages as high as 6.0 V or as low as 4.0 V. That is, voltages outside this range could potentially damage the interface circuitry **31**, as well as other components of the portable device **21**, for example. Yet, device type #2 could be damaged by voltages outside of the range from 4.8 to 5.25 V. There is also a significant overcurrent limit disparity between device types #1 and #2 (i.e., 800 mA vs. 400 mA).

[0038] Accordingly, a charger set up to charge a portable device of type #1 could cause significant damage to a portable device of type #2 by applying a current/voltage outside of the above-noted ranges. For example, exceeding the maximum battery charge current could cause damage to the battery. This may be particularly problematic where both portable device types use the same type of device connector (e.g., a USB connector). That is, a user may assume that because the device connecter matches that of the charger it is safe to use the charger, which may not be true.

[0039] Moreover, even if a charger detects the appropriate voltage level for charging a particular battery, as with the prior art discussed above, a

particular battery may support voltage or current levels inside the acceptable ranges for device type #1, but outside those for device type #2, for example. Thus, while the same battery type may fit in both device types and have a suitable operating voltage for both, charging the battery at or near its maximum charge limits could exceed the acceptable range for device type #2, as will be appreciated by those skilled in the art. Of course, the opposite is also true, namely that a given portable device could support charging parameters that could damage a particular battery type.

[0040] The battery charger **23** illustratively includes one or more memories **32** connected to the controller **27** for storing different portable device/battery charging parameters. That is, the memory **32** stores the appropriate device and battery charging parameters for each type of portable device and rechargeable battery **22** to be used with the battery charger **23**, which may be stored based upon respective device and battery IDs. By way of example, different sets of charging parameters may be stored in the memory during manufacture of the charger **23** for each device/battery type to be used with the charger. To this end, the memory **32** may be an EEPROM, for example, which would also advantageously allow for new charging parameters to later be stored therein, as will be discussed further below. Of course, other non-volatile (or even volatile) memories could be used as well.

[0041] The charger **23** checks to see whether the device and battery types are known based upon the device and battery IDs returned by the portable device, at Block **42**. If so, the controller provides an error

signal to the portable device **21**, at Block **43**, letting it know that it (or the battery **22**) is unknown and that cannot therefore cannot be performed.

[0042] In some embodiments, the battery charger **23** may further include an indicator **33** connected to the controller **27**, which may be used for providing an error indication upon detection of an unknown device/battery type. Of course, if the portable device **23** includes its own indicator or display (e.g., a laptop, PDA, cell phone, etc.), such an error indication may instead (or in addition) be provided by the device indicator (not shown). By way of example, the indicator **33** may be an LED or LCD indicator, although other suitable indicators could also be used, such as audible indicators.

[0043] Even if a device or battery type is unknown to the controller **27**, it may advantageously learn or download the appropriate charging parameters for the device/battery. This allows the charger **23** to be used with future generations or models of devices/batteries that are not available when the battery charger **23** is manufactured, for example.

[0044] More specifically, the controller **27** may enter a learning mode for learning the new device/battery parameters upon receiving a learning mode signal from the portable device **21**, at Block **44**. For example, the portable device **21** may store its own charging parameters and, responsive to receiving an unknown device error signal from the controller **27**, send a designated learning mode signal that the battery charger **23** will recognize as such. The charging parameters for the rechargeable battery **22** may be stored in its identification circuit, for example.

[0045] Once the controller **27** enters the learning mode, the microprocessor **30** of the portable device **21** then communicates the appropriate charging parameters to the controller, which it then stores in the memory **32**, at Block **45**. The newly learned charging parameters are then available for use in charging the device and/or battery type, and these device types will be recognized by the controller **27** thereafter. If a learning mode signal is not received, the battery charger **23** will stop the charging process (Block **52**).

[0046] If the device and battery types are recognized by the controller **27**, it then selects actual charging parameters for charging the rechargeable battery **22** based upon a comparison of the different charging parameters for the portable device **21** and battery **22**, at Block **46**. More particularly, the controller **27** may select the actual charging parameters based upon a limiting one (or ones) of the different portable device an battery charging parameters, at Block **46**.

[0047] Using the above exemplary charging parameters from Tables 1 and 2, for example, if a device of type #2 with a battery of type #1 is being charged, the controller **27** may limit the charging time to four hours, even if the battery voltage has not reached the maximum charge level of 4.22 V for the device. Similarly, the controller **27** may also limit the charging current to 400 mA or charging voltage to within the 4.8 - 5.25 V range, even though the battery type may support other values. Various other selections of limiting charging parameters are possible, as will be readily apparent to those of skill in the art based upon the examples provided herein.

[0048] Once the actual charging parameters are established, the charger **23** then causes the charging circuit **26** to charge the battery **22** in accordance with these actual charging parameters, at Block **47**. The charging circuit **26** may include a power supply or transformer for converting power from either an AC or DC source to the appropriate charging voltage based upon the actual charging parameters. Of course, the charging circuit **26** need not include a power supply/transformer in all embodiments. For example, in some applications the charging circuit **26** may receive power (i.e., 5 V) from the host device via the V_{BUS} line. Moreover, the power supply may be carried in a different housing than the controller **27**, for example, such as in the case of a wall plug transformer. Various configurations of the charging circuitry **26** will be readily apparent to those skilled in the art based upon a given application.

[0049] The controller **27** may also cause the portable device **21** to identify a battery charge level of the battery **22** and use this information in establishing the actual charging parameters. For example, the battery charge level may be communicated to the controller **27** by the microprocessor **30** along with the portable device and battery types (Block **41**). The battery charge level may also be sent to the controller **27** during charging, if desired, to help determine when the battery **22** has reached its full charge. This could be done automatically by the microprocessor **30** at predetermined intervals, or upon request by the controller **27**, for example. The controller **27** may also determine when the battery **22** has been fully charged based upon a charging parameter, e.g., a steady state current value which

indicates when a battery has been completely charged, for example.

[0050] In addition, the controller **27** may also monitor the charging circuit **26** to detect a charging error during charging of the battery **22**, at Block **50**. By way of example, such charging errors may include over or undervoltage conditions, over or undercurrent conditions, excessive temperatures, etc. Upon detecting such an error, the controller **27** may provide an error indication via the indicator **33** (and/or an indicator of the portable device **21**) upon detecting a charging error. The controller **27** may also take corrective action responsive to the error condition, such as limiting the charging voltage or current, or terminating charging, as illustratively shown at Block **52**. If no such error is detected, then charging continues until a predetermined event occurs, such as a maximum charging time or charge level being reached, at Block **53**.

[0051] In accordance with another advantageous aspect of the invention, the charger connector **24** may also carry communications signals between the controller **27** and the host device. For example, the controller **27** may communicate with the host device over the same differential signal lines D+, D- connected to the charger connector **24**. In particular, the communications signals may relate to one or more charging parameters. That is, the controller **27** may download charging parameters for unknown device/battery types from the host device instead of, or in addition to, downloading charging parameters from portable devices themselves.

[0052] Of course, this configuration also allows the charger connector **24** to carry communications signals between the portable device **21** and the host device. In other words, the battery charger **23** may thus be used as a docking station for allowing the portable device **21** to communicate with the host device while it is being charged. This arrangement may be particularly advantageous for portable devices such as PDAs. This is because PDAs not only have portable batteries which typically require regular re-charging, but they also typically need to synchronize calendar, contact, email, and other data with a computer, as will be appreciated by those of skill in the art.

[0053] A battery charging method aspect of the invention for a rechargeable battery **22** carried by a portable device **21** includes coupling a device connector **25** of the portable device to a corresponding charger connector **24**, and connecting a charging circuit **26** to the charger connector. The method may further include causing the portable device **21** to identify its corresponding portable device type and its corresponding rechargeable battery type from among a plurality of different portable device types and different battery types, and causing the charging circuit **26** to charge the rechargeable battery **22** based thereon, as previously described above. Additional method aspects will be readily apparent to those skilled in the art based upon the foregoing description and will therefore not be discussed further herein.

EXAMPLE

[0054] Turning now to FIG. 5, an exemplary portable or mobile device **1000** illustratively includes a housing

1200, a keyboard **1400** and an output device **1600.** The output device shown is a display **1600,** which is preferably a full graphic LCD. Other types of output devices may alternatively be utilized. A processing device **1800** is contained within the housing **1200** and is coupled between the keyboard **1400** and the display **1600.** The processing device **1800** controls the operation of the display **1600,** as well as the overall operation of the mobile device **1000,** in response to actuation of keys on the keyboard **1400** by the user.

[0055] The housing **1200** may be elongated vertically, or may take on other sizes and shapes (including clamshell housing structures). The keyboard may include a mode selection key, or other hardware or software for switching between text entry and telephony entry.

[0056] In addition to the processing device **1800,** other parts of the mobile device **1000** are shown schematically in FIG. 5. These include a communications subsystem **1001;** a short-range communications subsystem **1020;** the keyboard **1400** and the display **1600,** along with other input/output devices **1060, 1080, 1100** and **1120;** as well as memory devices **1160, 1180** and various other device subsystems **1201.** The mobile device **1000** is preferably a two-way RF communications device having voice and data communications capabilities. In addition, the mobile device **1000** preferably has the capability to communicate with other computer systems via the Internet.

[0057] Operating system software executed by the processing device **1800** is preferably stored in a persistent store, such as the flash memory **1160,** but may be stored in other types of memory devices, such as a read only memory (ROM) or similar storage element. In

addition, system software, specific device applications, or parts thereof, may be temporarily loaded into a volatile store, such as the random access memory (RAM) **1180**. Communications signals received by the mobile device may also be stored in the RAM **1180**.

[0058] The processing device **1800**, in addition to its operating system functions, enables execution of software applications **1300A-1300N** on the device **1000**. A predetermined set of applications that control basic device operations, such as data and voice communications **1300A** and **1300B**, may be installed on the device **1000** during manufacture. In addition, a personal information manager (PIM) application may be installed during manufacture. The PIM is preferably capable of organizing and managing data items, such as e-mail, calendar events, voice mails, appointments, and task items. The PIM application is also preferably capable of sending and receiving data items via a wireless network **1401**. Preferably, the PIM data items are seamlessly integrated, synchronized and updated via the wireless network **1401** with the device user's corresponding data items stored or associated with a host computer system.

[0059] Communication functions, including data and voice communications, are performed through the communications subsystem **1001**, and possibly through the short-range communications subsystem. The communications subsystem **1001** includes a receiver **1500**, a transmitter **1520**, and one or more antennas **1540** and **1560**. In addition, the communications subsystem **1001** also includes a processing module, such as a digital signal processor (DSP) **1580**, and local oscillators (LOs) **1601**. The specific design and implementation of

the communications subsystem **1001** is dependent upon the communications network in which the mobile device **1000** is intended to operate. For example, a mobile device **1000** may include a communications subsystem **1001** designed to operate with the Mobitex™, Data TAC™ or General Packet Radio Service (GPRS) mobile data communications networks, and also designed to operate with any of a variety of voice communications networks, such as AMPS, TDMA, CDMA, PCS, GSM, etc. Other types of data and voice networks, both separate and integrated, may also be utilized with the mobile device **1000**.

[0060] Network access requirements vary depending upon the type of communication system. For example, in the Mobitex and DataTAC networks, mobile devices are registered on the network using a unique personal identification number or PIN associated with each device. In GPRS networks, however, network access is associated with a subscriber or user of a device. A GPRS device therefore requires a subscriber identity module, commonly referred to as a SIM card, in order to operate on a GPRS network.

[0061] When required network registration or activation procedures have been completed, the mobile device **1000** may send and receive communications signals over the communication network **1401**. Signals received from the communications network **1401** by the antenna **1540** are routed to the receiver **1500**, which provides for signal amplification, frequency down conversion, filtering, channel selection, etc., and may also provide analog to digital conversion. Analog-to-digital conversion of the received signal allows the DSP **1580** to perform more complex communications functions, such as demodulation and decoding. In a similar manner,

signals to be transmitted to the network **1401** are processed (e.g. modulated and encoded) by the DSP **1580** and are then provided to the transmitter **1520** for digital to analog conversion, frequency up conversion, filtering, amplification and transmission to the communication network **1401** (or networks) via the antenna **1560**.

[0062] In addition to processing communications signals, the DSP **1580** provides for control of the receiver **1500** and the transmitter **1520**. For example, gains applied to communications signals in the receiver **1500** and transmitter **1520** may be adaptively controlled through automatic gain control algorithms implemented in the DSP **1580**.

[0063] In a data communications mode, a received signal, such as a text message or web page download, is processed by the communications subsystem **1001** and is input to the processing device **1800**. The received signal is then further processed by the processing device **1800** for an output to the display **1600**, or alternatively to some other auxiliary I/O device **1060**. A device user may also compose data items, such as e-mail messages, using the keyboard **1400** and/or some other auxiliary I/O device **1060**, such as a touchpad, a rocker switch, a thumb-wheel, or some other type of input device. The composed data items may then be transmitted over the communications network **1401** via the communications subsystem **1001**.

[0064] In a voice communications mode, overall operation of the device is substantially similar to the data communications mode, except that received signals are output to a speaker **1100**, and signals for transmission are generated by a microphone **1120**.

Alternative voice or audio I/O subsystems, such as a voice message recording subsystem, may also be implemented on the device **1000**. In addition, the display **1600** may also be utilized in voice communications mode, for example to display the identity of a calling party, the duration of a voice call, or other voice call related information.

[0065] The short-range communications subsystem enables communication between the mobile device **1000** and other proximate systems or devices, which need not necessarily be similar devices. For example, the short-range communications subsystem may include an infrared device and associated circuits and components, or a Bluetooth™ communications module to provide for communication with similarly-enabled systems and devices.

[0066] Many modifications and other embodiments of the invention will come to the mind of one skilled in the art having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is understood that the invention is not to be limited to the specific embodiments disclosed, and that modifications and embodiments are intended to be included within the scope of the appended claims.